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Comparative evaluation of yield and chemical composition of the pearl millet hay

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ABSTRACT

Depending on sowing time, the highest yield of hay was obtained by sowing in the second part of May - 6.1 t / ha. Irrigation provided an increase in hay yield, depending on the sowing time, from 0.7 to 5.6 t / ha. In the second part of May, a large amount of crude protein, ash, soluble carbohydrates and carotene was obtained in the crabgrass hay, and amounted to 12.5, 8.8, 3.9% and 195.3 mg/kg, respectively. Also, the highest values of crude protein, ash, soluble carbohydrates and carotene were observed during irrigation, and amounted to 12.7, 8.8, 3.2% and 189.9 mg/kg. The amount of crude cellulose, depending on the agrotechnical measures, changed insignificantly. The content of crude fat in the pearl millet hay, according to the agrotechnical measures, did not change, and was equal to 1.7%. Depending on the phase of development, the highest amount of crude protein, ash, fat and carotene was observed in the phase of leaf-tube formation, and amounted to 11.3, 10.9, 8.2% and 197.2 mg/kg, respectively. Most of the soluble carbohydrates were determined in the ear formation phase (11.0%), crude cellulose in the flowering phase (39.8%). As a result of the studies, with the best conditions, for obtaining a higher and qualitative yield of the pearl millet hay the sowing time was fixed in the second part of May, without irrigation, and harvesting in the early phases of vegetation (leaf-tube formation and ear formation). It is also determined that the use of irrigation in the cultivation of pearl millet ensures high yield and quality of hay.

Key words : *Pearl millet, Penisetum tiphoideum, Sowing time, Irrigation, Development phases, Chemical composition, Protein, Cellulose, Carotene*

Introduction

The state of fodder production in the country, due to the low productivity of seeding of annual fodder crops, so far lags far behind the needs of animal husbandry both in quantity and in quality of the produced forage. One of the reasons for the low productivity of seeding of annual fodder crops in the Republic of Kazakhstan is the imperfection of the species composition. A small species diversity of cultivated crops creates certain problems, both in the world and domestic agriculture. This led to the fact that in many farms the animals were not provided with sufficient fodder. Their quality was sharply deteriorated. As a result, the level of provision with high-quality fodder remains low, the optimum structure of the ration of feeding by the types of feed has been disrupted. Very low is the index of laying-in of succulent feed, which causes unbalanced feeding in terms of content and ratio of nutrients. The discrepancy between feed requirements and their availability, unsatisfactory feed balance structure, high feed costs are the main reasons for incomplete use of animal production opportunities, low feed efficiency and high cost price of livestock products (Serekpaev *et al*., 2013; Serekpaev *et al*., 2016; Mukhanov *et al*., 2018).

To reduce the cost of feed rations, it is important to expand the set of fodder crops characterized by good fodder advantages, the highest and stable yields, lower power inputs for cultivation, and less demanding agroclimatic conditions. This is one of the ways to create a solid fodder base for livestock, while at the moment, creating a fodder base is an urgent problem of feed production (Mozhayev and Serekpayev, 2007).

One of the promising crops is pearl millet (*Penisetum tiphoideum rich*). It belongs to the group of tall, miliary crops and is the oldest grain crop in many countries of South and East Asia and West and Central Africa. In India, 75%, and in Africa, 95% of the total area of sowing of food miliary crops is occupied by pearl millet. However, in the countries of the CIS, pearl millet is of great interest as a fodder plant (Belitsky, 1957).

This crop attracts the attention of agricultural workers more and more by its drought resistance, low demand for soil conditions, high yield of green mass and good forage qualities. By drought resistance, it is superior to maize and not inferior to Sudan grass and sorghum. Pearl millet grows well even in arid conditions, and at the same time it gives several cuts for vegetation (Vysokos, 1958; Medvedev and Smetannikova, 1981; Kumawat *et al*., 2016; Shukis, 2013; Asmat *et al.,* 2017).

By fodder merits, pearl millet can be equated to annual crops (Sudan grass, sorghum, maize). According to Belitsky (1957), the green mass of pearl millet, in protein and protein content, can be equated to Sudan grass and exceeds maize and sorghum by the content of fat and nitrogen-free substances - there are no significant differences compared to Sudan grass, sorghum and maize. Pearl millet contains in the green mass a sufficient amount of ash elements, especially calcium and phosphorus, which significantly increases its value in the feed allowance of young animals.

According to Paramanov (1948), Romanenko *et al.* (1999), as well as Bugai (1963) pearl millet hay in chemical composition is not only inferior to other annual grasses, but even surpasses them in terms of the amount of the most valuable nutrients. According to Academician Larin (Zykov, 1969) and the data of other foreign scientists (Elfadil, 2014), it contains a large amount of protein and other nutrients. According to Shukis (2017), the protein content of pearl millet is 1-3% higher than some other annual grasses.

Green mass and hay of pearl millet are readily eaten by all kinds of farm animals. Easily available sugars in pearl millet hay are no less than in sorghum, so straw and green mass are well ensiled and give high-quality succulent animal feed. Grain is a valuable concentrated feed for birds (Korzun and Gest, 2010; Maisuryan *et al.,* 1965; Yelsukov, 1954; Kirillov, 1968; Sadikova *et al.,* 2016).

It is a promising forage crop for dry farming in semi-arid and arid zones of the Republic of Kazakhstan. Despite a number of merits of pearl millet, which have been described above, it was not widely spread in the steppe zone of the northern Kazakhstan. At the same time, in our country the technology of growing pearl millet has been studied very poorly, and it refers to insufficiently explored crops, which is one of the reasons that this crop is not used in specific soil and climatic conditions of the region.

In this regard, one of the research tasks was to determine the optimal growing conditions, the sowing time and the phase of harvesting of pearl millet for the steppe zone of the northern Kazakhstan. The solution of this task was carried out by studying the influence of the sowing time on the productivity of the pearl millet hay and their chemical composition; studying the dynamics of changes in the chemical composition of the pearl millet plants depending on the phase of growth and development.

Materials and Methods

Location of experiments

Experimental studies were conducted in 2016-2017 at the permanent establishment of the Department of Agriculture and Plant Growing of the Kazakh Agro Technical University named after S.Seifullin, located on the dark chestnut soils of the steppe zone of the northern Kazakhstan.

Object of research

The object of research was the mid-ripening variety of the pearl millet Sogur, bred by selection in the All-Russian Research Institute of leguminous and cereal crops (RF) (Zotikov *et al.,* 2012).

Applied research methods

The studies were carried out according to the method of Dospekhov (1985) and State testing of agricultural crops (2011)

The sowing and registration area of the plots is 2 m^2. Replication in the experiment is three-fold, the arrangement of the plots is systematic. Agrotechnics in the experiment, in addition to the studied techniques, is recommended for the zone. The main tillage was carried out; in winter - snow retention; in spring, with the onset of physical ripeness of the soil - the closure of moisture (grinding with simultaneous rolling). The sowing was carried out with the help of a selective manual drill with simultaneous laydown. The sowing of pearl millet was carried out in 3 terms: the first was in the second part of May (May 19), the second was in the third part of May (May 28) and the third sowing period was in the first part of June (June 7). The seeding rate was 1.0 million pieces per hectare, while the seeding depth was 3 cm, the seeding method was wide-row, with a row spacing of 30 cm. The calculations and observations were carried out according to generally accepted methods. Accounting for the yield of pearl millet hay depending on the sowing time was carried out by a weighting method in triplicate during the ear formation phase, that is, in 2016 in conditions without irrigation, on the sowings of the first sowing period was on July 23, the second was on August 5 and the third sowing period was 29 July, and under irrigation conditions it was on July 25, 28 and August 2, respectively. In 2017, the yield of pearl millet hay in the conditions without irrigation was taken into account on the first and second sowing periods on 28 and 31 July, and the third sowing period was on 5 August, under conditions of irrigation it was on 5, 7 and 10 August, respectively.

The lowest moisture capacity of the soil, under irrigation conditions, was determined in the field by the method of flooded areas (1 m^2) according to Kossovich with the natural addition of soil. The soil density was also determined by the method of cylinders according to Kaczynski (1965) along ten-centimeter layers of the soil section to a depth of 1 m. In the years of the study, during the vegetative period of the crops, the moisture in the meter layer of soil in the experimental area was determined by the thermostatic-weight method every 10 days.

The analysis of meteorological conditions was carried out according to the data of the field agrometeorological station "METOS".

The total water consumption (W_c) was calculated taking into account the actual reserve of productive moisture in a meter layer of soil, by adding the amount of moisture from precipitation during the vegetation period of the crop and subtracting the amount of residual moisture:

$W_c = M_s + M_p - M_{res}$,

where, M_s - reserves of productive moisture in a meter layer of soil, mm or m^3/ha; M_p is the total amount of precipitation during the vegetation period, mm or m^3/ha; M_{res} is the residual moisture - unused amount of productive moisture and remaining after ripening or harvesting crops, mm or m^3/ha.

The coefficient of water consumption ($W_{c\ (coef)}$) was calculated on the basis of actual indicators of total water consumption and hay yield:

$W_{c\ (coef)} = M_s + M_p - M_{res} / y$,

where y is the yield, t / ha (Mozhayev et al., 2009).

Method of chemical analysis

The determination of the nutrition of obtained feeds and their chemical composition was carried out in laboratories of LLP "Scientific and Innovative Center for Animal Husbandry and Veterinary Medicine" on the equipment - DS 2500 from the firm "Foss" and in FSBEI HE Orlov SAU, Innovative Scientific Research Test Center for Collective Use (Orel , RF). The conducted chemical analyzes corresponded to the following State standards: determination of dry matter, crude fat , crude ash, crude protein, and determining water-soluble carbohydrates (sugars).

To conduct chemical analysis of pearl millet, samples were taken in three phases - in the phase of leaf-tube formation, ear formation and flowering.

The dry matter of the selected samples was determined by drying to constant weight at a temperature of 100-105 °C. Chemical tests of the samples were carried out at a temperature of 25 °C and a relative humidity of 45%.

Soil conditions of the study

The analysis of the agrochemical survey of the soils of experimental plots was carried out in the specialized agrochemical laboratory of Ministry of Agriculture Republic of Kazakhstan. The agrochemical analysis of the soil in the experimental section included the determination of: the pH of the salt extract by the potentiometric method; humus - according to Tyurin, the content of mobile mineral forms of phosphorus and potassium - using the technology of CIACS in the coal-ammonium extract according to Machigin, the nitrogen content of nitrates - by the ionometric method.

The soil of the experimental site is dark chestnut, heavy mechanical composition. The thickness of the arable layer is 20 cm. The humus content in the arable horizon is from 0 to 20 cm - 2.09%, nitrate nitrogen is 7.15 mg/kg, mobile phosphorus is 12.51 mg/kg, exchange potassium is 583.50 mg/kg, $pH_{ñîë}$ is 6.91; in the 20-40 cm horizon the humus content is 2.53%, nitrate nitrogen is 4.10 mg / kg, the mobile phosphorus is 7.85 mg / kg, the exchange potassium is 468.50 mg / kg, and pH is 6.89 .

The results of the chemical analysis of the soil showed that in the 0-20 cm layer of the arable soil horizon, the content of mobile phosphorus is low, and in the horizon 20-40 cm horizon is very low (according to Machigin's gradation low is 11-15 mg / kg, very low is up to 10 mg / kg of soil), the content of exchangeable potassium in the 0-20 cm plowing horizon of the soil is elevated, and in the horizon 20-40 cm is high (according to Machigin's gradation, elevated is 401-500 mg/kg, high is 501-600 mg/kg of soil and above). The content of nitrate nitrogen in the 0-20 and 20-40 cm soil horizon is very low (according to Tyurin's gradation very low is to 30 mg/kg). According to the content of humus, the soil belongs to the poorly provided (according to Tyurin's gradation low is 2-4 mg/kg). The reaction of the soil solution is neutral.

Thus, dark chestnut soils have rather low potential fertility, since they have a low humus content. They have a high content of exchangeable potassium and a low content of readily hydrolyzable nitrogen and mobile phosphorus.

On average, for two years the soil density index in the arable layer of 0-20 cm was 1.13 g / cm^3 (on average over the horizon), in the 20-50 cm layer it was 1.33 g / cm^3, in the 50-100 cm layer - 1.51 g / cm^3 (Table 1).

The results obtained show that according to the Dolgov's scale (1986) 0-20 cm of the soil layer in the experimental site is medium-dense (1.10-1.20 g / cm^3), 20-50 cm of the soil layer is dense (1.30-1.40 g/cm^3), and the lower soil layers are packed (> 1.50 g/cm^3).

On an average, for two years the index of the lowest moisture capacity of the soil in the experimental plot was 21.54% or 187.83 mm. In the years of research on the site under irrigation, during the vegetation period, the soil moisture was kept at the level of the lowest moisture capacity of the soil.

Results

Climatic conditions of the study

The weather conditions in the years of research were developing in different ways. In 2017, the average daily air temperature in the vegetation period of pearl millet (May, June, July, August) was at the level of the average annual indicator, but for some months exceeded, and in 2016 the average daily temperature of water in the summer months, except August, was below the average annual value of 1.0 and 1.1 ° C, respectively (Table 2).

In the years of research, atmospheric precipitation fell unevenly during the vegetation period. In May, at the beginning of the vegetation period of crabgrass atmospheric precipitation was lower than

Table 1. Indicators of the density and the lowest moisture capacity of soil in 2016- 2017.

Horizon, cm	Density of soil, g/cm^3		The lowest moisture capacity of soil, %		The lowest moisture capacity of soil, mm	
	2016	2017	2016	2017	2016	2017
0-10	1.01	1.03	26.65	30.77	18.64	23,25
10-20	1.32	1.16	25.37	29.46	21.08	23.27
20-30	1.32	1.25	25.15	26.93	21.18	22.29
30-40	1,32	1.31	23.83	23.31	19.84	19.01
40-50	1.40	1.39	20.85	21.95	17.15	18.56
50-60	1.46	1.44	20.12	20.54	17.99	18.35
60-70	1.54	1.50	19.47	19.01	20.59	19.36
70-80	1.58	1.53	18.31	16.45	17.71	14.30
80-90	1.61	1.52	16.67	15.82	18.63	16.30
90-100	1.46	1.51	16.12	14.10	15.36	12.83

Table 2. Average daily air temperatures in 2016-2017 in comparison with AMC

Months	2016	2017	AMC
January	-14.5	-12.3	-15
February	-7.6	-14.2	-15.2
March	-0.6	-8.8	-8.8
April	9.9	5.9	5.1
May	14.2	14.8	13.3
June	18.3	21.5	19.3
July	19.8	20.3	20.9
August	20.1	19.9	18.1
September	15.5	12.4	17.1

the average annual indicator of 21.7-22.0 mm. In June and July atmospheric precipitation fell by 37.7 and 57.0 mm more than norm, and in August and September was by 24.9 and 12.6 mm less than the norm, respectively. In June and July 2017, atmospheric precipitation was 14.0 and 22.0 mm lower than the average long-term indicator, respectively,

Table 3. Number of precipitations for 2016-2017 in comparison with MPR (Mean perennial rainfall), mm

Months	2016	2017	MPR
January	19.8	20.8	18.0
February	10.1	22.5	14.0
March	19.3	15.5	14.0
April	35.6	36.0	23.0
May	12.3	12.0	34.0
June	73.7	22.0	36.0
July	106.0	27.0	49.0
August	4.1	29.0	29.0
September	9.4	17.0	22.0

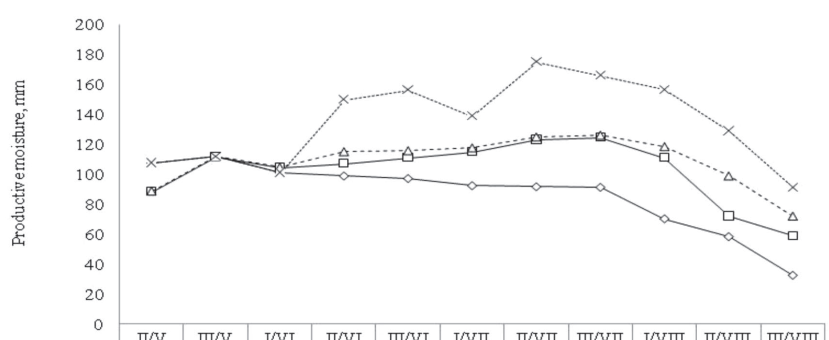
and in August was at the level of mean annual data. In September, it was 3.0 mm lower than the norm (Table 3).

In the research years, the change in productive moisture in a meter layer of soil was associated with the arrival of atmospheric precipitation. In 2016, the indicator of reserves of productive moisture in the soil was high, with the largest number recorded in July, and ranged from 114.8 to 124.4 mm, depending on the decade of the month. During the period of research this indicator was quite high, as in July 2017 the reserves of productive moisture in the soil in the first decade amounted to 92.4 mm, while decreasing by the end of the month to 91.3 mm. Absence of precipitation in 2017 for all months, except for the third decade of May, contributed to a decrease in productive moisture in a meter layer of soil (Figure 1).

Calculations of the hydrothermal coefficient characterized the meteorological conditions of 2016 as moderately arid (HTC = 0.82), the conditions of 2017 as very arid (HTC = 0.32).

In the years of undertaking studies, the productive moisture in a meter layer of soil in the irrigation areas was at the site level without irrigation during the period from the second decade of May to the first ten days of June, and from the second decade of June to the end of August, thanks to irrigation, it was somewhat higher.

On average, for two years the productive moisture in a meter layer of the soil on the site without irrigation was 104.9 mm in May, 103.3 mm in June, 106.3 in July and 67.2 mm in August, and in the ir-



	II/V	III/V	I/VI	II/VI	III/VI	I/VII	II/VII	III/VII	I/VIII	II/VIII	III/VIII
without irrigation 2017	107,6	112,0	101,2	98,9	97,2	92,4	91,7	91,3	70,2	58,2	32,3
without irrigation 2016	88,5	111,6	104,3	107,2	110,9	114,8	122,8	124,4	110,9	72,2	59,1
with irrigation 2016	88,5	111,6	104,3	114,8	115,5	117,3	124,6	125,8	118,2	98,6	71,7
with irrigation 2017	107,6	112,0	101,2	149,6	156,2	138,8	174,8	165,7	156,4	128,8	91,3

Decades of the Months

Fig. 1. The dynamics of productive moisture in a meter layer of soil in the experimental plot for 2016-2017, mm

rigation section it was equal to 105.0, 123.6, 141.2 and 110.8 mm, respectively.

In the research years, the total water consumption of the pearl millet in conditions without irrigation was 874.5 mm at the first sowing period, 859.2 mm at the second sowing period and 732.0 mm at the third sowing period, and at a level of irrigation conditions it was 1106.8, 1040.7 and 972.4 mm respectively (Table 4).

In 2016, the water consumption rate of pearl millet in conditions with irrigation was lower than under conditions without irrigation at the first seeding period by 1.0 mm / c, at the second - by 27.8 and at the third sowing period by 10 mm / c. In 2017, in sowings with irrigation, the most economical use of water to form a crop unit from the sowing area was observed at the second and third sowing times, and amounted to 13.7 and 14.5 mm, and a high water consumption coefficient was noticed at the first sowing period. On average, in two years the coefficient of water consumption of pearl millet in conditions without irrigation made 14.0 mm / c at the first sowing time, 32.7 mm in the second sowing time and 19.7 mm / s in the third sowing time, and in conditions with irrigation it was respectively 17.2, 12.6 and 12.8 mm / c, respectively. That is the most economical consumption of water for the formation of hay yield was observed with irrigation and later sowing time.

The yield of pearl millet hay depending on agro technical measures

The observations showed that on average for 2016-2017 there was a significant advantage of the first sowing time in the productivity of pearl millet hay. On average, for two years, in conditions without irrigation, the yield of pearl millet hay at the first sowing time was 6.1 tons / ha, at the second it was 2.7 and at the third sowing time it was 3.7 tons / ha, that is, the first sowing time provided 48.8% of the hay yield, the second provided 21.6% and the third sowing time provided 29.6% (Table 5, Figure 2).

In addition, for the years of research, a high advantage of irrigation of pearl millet was observed during the formation of hay, especially at later sowing times.

Table 4. Total water consumption (W_c) and coefficient of water consumption ($W_{c\,(coef)}$) of pearl millet for the formation of hay yield, depending on agrotechnical measures

Sowing time	Without irrigation				With irrigation			
	2016		2017		2016		2017	
	W_c, mm	$W_{c\,(coef)}$, mm/c	W_c, mm	$W_{c\,(coef)}$, mm/c	W_c, mm	$W_{c\,(coef)}$, mm/c	W_c, mm	$W_{c\,(coef)}$, mm/c
II/V (St)	965,3	14,0	783,7	13,9	1040,3	13,0	1173,2	21,3
III/V	1016,7	39,3	701,1	26,0	957,7	11,5	1123,6	13,7
+,- ê St	+96,4	+25,3	-82,6	+12,1	-82,6	-1,5	-49,6	-7,6
I/VI	838,5	21,0	625,4	18,4	883,4	11,0	1061,4	14,5
+,- ê St	-126,8	+7,0	-158,3	+4,5	-156,9	-2,0	-111,8	-6,8

Table 5. The yield of pearl millet hay depending on agro technical measures, t/ha

Sowing time	Replication	Without irrigation				With irrigation			
		2016	+,-for St	2017	+,- for St	2016	+,- for St	2017	+,-for St
II/V (St)	I	5,1	-	6,8	-	8,4	-	4,9	-
	II	8,8	-	5,2	-	6,5	-	5,5	-
	III	6,7	-	3,8	-	9,1	-	6,1	-
III/V	I	2,3	-2,8	3,3	-3,5	8,0	-0,4	8,3	+3,4
	II	2,5	-6,3	2,8	-2,4	9,5	+3,0	9,2	+3,7
	III	3,2	-3,5	2,0	-1,8	7,3	-1,8	7,0	+0,9
I/VI	I	4,0	-1,1	2,7	-4,1	8,1	-0,3	7,0	+2,1
	II	4,5	-4,3	4,3	-0,9	7,5	+1,0	5,6	+0,1
	III	3,5	-3,2	3,2	-0,6	8,4	-0,7	9,4	+3,3
SSD_{05}		2,3	-	2,1	-	2,0	-	2,6	-

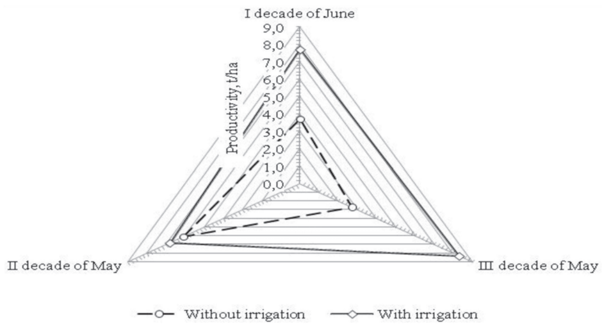


Fig. 2. The yield of pearl millet hay depending on agro technical measures, t / ha

On average, for two years in conditions with irrigation, the yield of hay was 6.8 t / ha at the first sowing time, 8.3 at the second, and 7.7 t / ha in the third sowing time. So, in comparison with the conditions without irrigation, crops in conditions with irrigation provided an increase in hay yield at the first sowing time by 0.7 t / ha, at the second - 5.6 and at the third sowing time - 4.0 t / ha.

The change in the chemical composition of pearl millet hay depending on agro technical measures

In the analyzed years, according to the results of the chemical analysis, the content of crude protein in the pearl millet hay, which determines the feed value of the vegetative mass of any plant species, was higher at the first sowing time, and amounted to 12.5%. The content of crude cellulose in the pearl millet hay, depending on the sowing time, was slightly higher at later sowing times (Table 6).

The sowing time did not affect the content of crude fat, which was 1.7%, for all sowing times. The amount of crude ash was slightly higher at the first sowing time, and amounted to 8.8%. The highest indices of soluble carbohydrates and carotene in the pearl millet hay were observed at the first sowing time, and amounted to 3.9% and 195.3 mg / kg, respectively.

The highest content of crude protein was observed in conditions with irrigation and amounted to 12.7%. The amount of crude cellulose and ash was slightly higher in conditions with irrigation, and, accordingly, was 33.0 and 8.8%. Irrigation did not affect the content of crude fat in the hay (Table 7).

The highest indicators of soluble carbohydrates and carotene in the pearl millet hay of were observed in conditions with irrigation, and amounted to 3.2% and 189.9 mg / kg, respectively.

Mathematical processing of the data showed that the amount of the content of crude protein, ash, soluble carbohydrates and carotene is directly correlated with the yield of the pearl millet hay. The correlation coefficient between the yield of hay with

Table 6. The chemical composition of the pearl millet hay depending on the sowing time, % (for 2016-2017)

Indicators	II decade of May (St)	III decade of May	+,- for St	I decade of June	+,- for St
Water	25,0	23,0	-2,0	24,7	-0,3
Crude protein	12,5	11,7	-0,8	11,3	-1,2
Crude cellulose	32,2	33,0	+0,8	33,0	+0,8
Crude fat	1,7	1,7	-	1,7	-
Crude ash	8,8	8,2	-0,6	8,4	-0,4
Soluble carbohydrates	3,9	2,3	-1,6	2,4	-1,5
Carotene, mg/kg	195,3	184,7	-10,6	181,6	-13,7

Table 7. The chemical composition of pearl millet hay depending on irrigation, % (for 2016-2017)

Indicators	Without irrigation (St)	With irrigation	+,- for St
Water	24,2	20,6	-3,6
Crude protein	11,8	12,7	+0,9
Crude cellulose	32,4	33,0	+0,6
Crude fat	1,7	1,7	-
Crude ash	8,5	8,8	+0,3
Soluble carbohydrates	2,9	3,2	+0,3
Carotene, mg/kg	187,2	189,9	+2,7

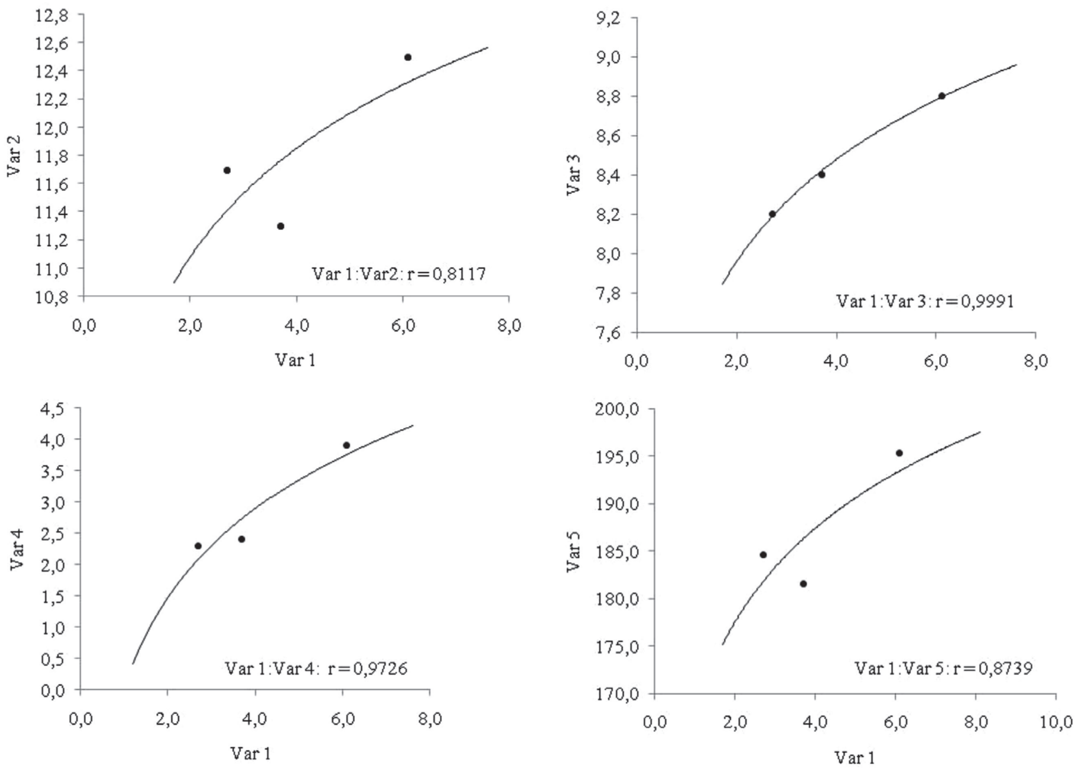
crude protein is 0.81, the ash content is 0.99, soluble carbohydrates is 0.97 and carotene is 0.87 (Figure 3). The correlation of hay yield with crude cellulose, as well as with crude fat is not revealed.

In addition, there was a strong relationship between the yield of hay obtained by irrigation and the crude protein, crude fiber, ash, soluble carbohydrates and carotene, with a correlation coefficient of 1.0.

From the above-stated it follows that the higher is the yield of hay obtained by applying certain agro technical measures, the better is the nutrient content in it.

The change in the chemical composition of pearl millet hay depending on the phase of development

The highest indicators of the amount of crude protein in the pearl millet hay were noticed in the early phases of development. In the phase of exit into the tube, they amounted to 11.3% and increased to the phase of sweeping by 4.3%, and to the flowering phase by 4.9%. As the vegetation of plants increased, the content of raw fiber in the hay increased. It amounted to 39.8% in the flowering phase, 32.3% in the sweep phase and 25.3% in the phase of the leaf-tube formation (Table 8).



Note: Var 1 - the yield of hay, t / ha; Var 2 - crude protein,%; Var 3 - crude ash,%; Var 4 - soluble carbohydrates,%; Var 5-carotene, mg /kg.

Fig. 3. The correlation dependence of the chemical composition with the productivity of pearl millet hay

Table 8. The chemical composition of pearl millet hay depending on the phase of development, % (for 2016-2017)

Indicators	Leaf-tube formation	Ear formation	Flowering
Water	9,0	9,0	8,0
Crude protein	11,3	7,0	6,4
Crude cellulose	25,3	32,3	39,8
Crude fat	8,2	7,4	7,8
Crude ash	10,9	8,0	7,7
Soluble carbohydrates	9,1	11,0	9,5
Carotene, mg/kg	197,2	187,2	189,6

The highest indicators of crude fat and crude ash were observed in the phase of the leaf-tube formation, and amounted to 8.2 and 10.9%, respectively. A large number of soluble carbohydrates was observed in the phase of ear formation, and amounted to 11.0%. The content of carotene was higher in the phase of the leaf-tube formation, and amounted to 197.2 mg/kg, while it increased to the spotting phase by 10.0 mg/kg and flowering by 7.9 mg/kg.

When increasing the dry matter in the plant, the content of crude cellulose also increased, with a correlation coefficient of 0.88.

Discussion

During the years of research in conditions without irrigation, the availability of soil moisture was a limiting factor, because in conditions of low water availability, the water consumption of pearl millet was higher, and, accordingly, more reserves of productive soil moisture were required than in conditions with irrigation. Consequently, this had a strong impact on the quality and productivity of pearl millet. In the years of research, the highest yield of pearl millet hay was obtained at the first sowing time - in the second part of May. Also the highest indicators of crude protein, ash, soluble carbohydrates and carotene were noticed at the first sowing time. Similar data were obtained in the experiments of Abd El-Lattief (2011) in the northern Egypt. According to the results of the experiment, the crops in the second part of May formed the highest yield of hay, and the amount of crude protein, depending on the sowing time, remained unchanged. Similar data were obtained in the experiments of Zhixin Zhanga *et al.* (2017) in the northern China. The presented facts indicate that at the early sowing times we are able to obtain a high yield of hay from annual fodder crops, and later sowing times do not influence the content of crude protein, the increase of which is noticed only in Sudan grass. In addition, it should be noted that in the experiments of the scientists Foster and Malhi (2013) in Northeast Saskatchewan, Canada, completely opposite data were obtained - the latest sowing times proved to be optimal for obtaining a high and full-grown yield hay of annual fodder crops.

The high content of the chemical composition of pearl millet hay was noticed in conditions with irrigation. Similar data were obtained in the experiments of Bhunia et al (2016), conducted in India in the arid zone of the western Rajasthan. An increase in the quality of pearl millet hay yield with irrigation and with an increase in the lowest moisture capacity of the soil, from 40% to 80% was observed. According to the Indian scientist Reddy *et al*. (2003), depending on the sowing time, the amount of harvest of many fodder crops may change, meanwhile it may not affect the quality, and irrigation of crops, especially in their critical phases, unambiguously leads to an increase in the yield of hay and crude protein.

According to Tyutyunnikov (1973) in the experiments of the Moscow zootechnical experimental station, the improvement of the water regime of the soil contributed to an increase in the protein content in many fodder crops, thereby increasing the total fodder value of the plant. In his opinion, the influence of moistening conditions on the chemical composition of plants is due to the fact that water serves as the most important reagent for the transformation of mineral and organic substances in the plant organism.

In the process of growth and development of the plant, its chemical composition changes. In the years of research, as the plants grew vegetative, the content of cellulose in dry matter of pearl millet increased and the amount of crude protein and other nutrients was reduced. Similar data were obtained in the experiments of Mehmood *et al.* (2016) in Pakistan on pearl millet crops, according to the results of the studying of which, an increase in yields was noticed, but the delay in harvesting was accompanied by decline in quality indicators (crude protein, ash, etc.). In the experiments of Khazov (2016), conducted in the western Siberia, high yield and nutrient content of pearl millet in the phase of ear formation was noticed. And also at the later phases of development, an increase in hay yield was observed, but quality indicators were declined. According to the the Russian scientist Tutyunnikov (1973), with the age of plants, due to the reduction in leaf formation, the chemical composition of almost any plant species decreases, since nutrients, especially crude protein, are more contained in leaves than in stems.

In addition, it should be mentioned that the indicator of the total amount of carotene, depending on the agro technical activities and the development phase of pearl millet was low. It is explained by the destruction of carotene in plants under strong sunlight and air temperature, previously observed in Tsvetova's experiments, these phenomena were typical in the conditions of 2017.

Conclusion

As a result of studies conducted in the steppe zone of the northern Kazakhstan, the formation of the highest yield of pearl millet hay with a high content of nutrients was observed during sowing in the second decade of May. In this case, irrigation provided an additional yield of hay with a high content of nutrients. It is also necessary to note a regular decrease in nutritional elements, and an increase in the cellulose content, as plants grow. The most optimal amount of nutrients in the plant was found in the leaf-tube formation and ear formation phases.

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